CRITICISMS AND DISCUSSIONS.

'A STRANGE ATTACK ON SOME PHYSICAL THEORIES."

Under the above quoted head, in *The Monist* for January 1900, Antonio Llano criticises an article by the present writer which appeared in *The Monist* for October, 1899. Mr. Llano does not discuss the contentions of the article which he criticises; but, after the manner of some controversialists, attempts to discredit the conclusions by apparently absurd conclusions drawn from the premises assumed. His article is devoted to showing that certain theories "are not original with Mr. Chase"; to pointing out "Mr. Chase's great error"; to waving aside, without argument, the "conclusions from formulas the exact meaning of which does not seem to be very clear to him" (Mr. Chase); and to animadversions on matters in regard to which "Mr. Chase seems to be somewhat confused."

In the article which Mr. Llano criticises I am somewhat at fault for not stating that formulas (4), $M=\frac{1}{2}(m+m')(v+v')$, and (6) $E'=\frac{1}{2}(m+m')\frac{(v+v')^2}{4}$, are not general, but particular cases of the general formulas which answer the same purpose in argument and have an advantage over the somewhat involved and complicated general formulas. These formulas, (4) and (6), are true only for the particular case of collision of bodies of equal masses, the case of $m=m'$. The general formulas would be, $M=(m+m')v''$, in which v'', the velocity of motion after impact, is, in magnitude, $\frac{mv+m'v'}{m+m'}$; and $E'=\frac{1}{2}(m+m')v''^2$, in which v'' is also, in magnitude, $\frac{mv+m'v'}{m+m'}$. Mr. Llano need not to have transformed the formulas to draw his conclusion that the bodies must be equal in mass, or weight; a simple inspection would have told him that.

So Mr. Llano's deduction from "'generalised' formula that all the bodies in the universe have either the same mass or the same velocity, or both the same mass and the same velocity," is a bit of sarcasm which has its fangs drawn as soon as we learn that the formulas were assumed for bodies of equal mass and moving in the same line of motion in the same direction.

Mr. Llano's "equally interesting and astounding conclusion" drawn from the formula, $E'=\frac{1}{2}(m+m')\frac{(v+v')^2}{4}$, upon which he comments facetiously, falls innocent of any damage to the argument which he seeks to discredit. In fact, the for-

mulas are rigorously true, limited to the particular case above stated. Mr. Llano should show how it is possible for both energy and motion to be conserved, on the theory that all energy is but matter in motion, rather than resort to the sophistical method of drawing attention from the main contention by seeking to deduce absurd conclusions from an adversary's premises.

In concluding his facetiae on formula (6) he says: "This 'Law' can be applied in 'practice' with most wonderful results. Thus, a 10,000-ton man-of-war, hit from beneath by a bullet weighing 2 or 3 ounces, could easily be hurled into the air with a velocity of 1000 feet per second."

I will not comment upon this statement further than to say that this "wonderful conclusion" is quite a vagary of Mr. Llano's imagination, and is as irrelevant to the question at issue as the animadversions of Mr. Dooley upon war, literature, and philosophy.

Again he says: "Mr. Chase further concludes, from some simple mechanical formulas the exact meaning of which does not seem very plain to him, that 'it is evident that kinetic energy is not wholly dependent on matter and motion.' Mr. Chase will not, we hope, accuse us of promulgating 'errors' and 'absurdities' if we tell him that *by definition*, kinetic energy is energy due to motion; indeed the term is often defined by mathematicians as a name given to the product $\frac{1}{2}mv^2$. What would a mechanician say to any one who told him that the velocity of a moving body does not depend upon time and space?"

In this instance also Mr. Llano has drawn an irrelevant conclusion. It is true that there can be no kinetic energy without motion; but the contention is that "kinetic energy is not wholly dependent on matter and motion," not that it does not depend on motion. The contention is that a factor which I will term "mass," or "inertia," is lost sight of in the formula as generally understood, and that this factor is involved in the term m; that what is commonly designated "mass" is really made up of two factors, the amount of matter and the "mass" as defined by J. Clerk Maxwell. On the theory that kinetic energy is wholly dependent on the amount of matter and the amount of motion, will Mr. Llano explain why two pound weights moving over a unit space in a unit of time have only half the energy of a one pound weight moving over two units space in a unit of time—the second case having but half the amount of matter and the same amount of motion as the first case, yet yielding double the amount of energy? This explanation will count for much more than conclusions drawn from arbitrary definitions. And it will not be out of place here to call attention to Mr. Llano's error in stating the formula for the energy of two inelastic bodies after collision. It is not $E-\frac{1}{2}\frac{mm'}{m+m'}(v-v')^2$, as Mr. Llano states, but is accurately expressed by the more complicated formula, $E'=E-\frac{1}{2}\left[m\left(v-\frac{mv+m'v'}{m+m'}\right)^2+m'\left(\frac{mv+m'v'}{m+m'}-v'\right)^2\right]$. For a full discussion of which subject, consult Thomson and Tait's *Treatise on Natural Philosophy*, Vol. I., pages 219–327.

Again Mr. Llano objects to the argument drawn from the parallelogram of

forces, saying that the resultant would be a parabola and not a straight line, in case of a force impressed at right angles to the line of motion of a particle. His statement would be true in case of a force gradually impressed in a direction constantly parallel to a normal to the original line of motion of the particle. But if the forces are impressed simultaneously on the particle and in lines at right angles to each other; or in case of a particle moving uniformly in a straight line and the instantaneous impression of a force at right angles to the line of motion of the particle—the impression of an infinite force in an infinitesimal period of time—the resultant is a straight line, the diagonal of the parallelogram of forces. In either of these cases the kinetic energy of the particle would be changed. It is, of course, true that, given a particle moving uniformly in a straight line and a force be impressed upon it continuously changing in direction so that the line of direction of the force shall be constantly normal to the line of motion of the particle, it would move with unchanged velocity and energy in a circle, an inwinding spiral, or an outwinding spiral, as the force is constant, increasing, ar decreasing. This, however, is a particular case of a general problem.

If Mr. Llano, or any other defender of the proposition, for that matter, wishes to defend and maintain the position, "that all phenomena can be reduced to matter and motion," it will devolve upon him to explain away the difficulties pointed out in the article of October 1899, in *The Monist*, under the heading, "The Doctrine of Conservation of Energy in Its Relation to the Elimination of Force as a Factor in the Cosmos." His article in the January *Monist* has not even touched upon, to say nothing of removing, the difficulties in the way of the proposition above stated.

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